Technology: Making Science Possible

NASA's Earth Science Enterprise

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Office of Earth Science

Earth Science Technology Conference

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Why We Are Here

- ESE is charged with answering specific, societally important science questions
- We have invested in key technologies to help us answer those questions over the next decade or more
- This conference serves to showcase these technologies, and to...

Catalyze the networking of scientists and technologists around our latest technologies to enable the former to generate better proposals for our upcoming solicitations

Earth Science Enterprise Mission:

Develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather and natural hazards for present and future generations

GOALS

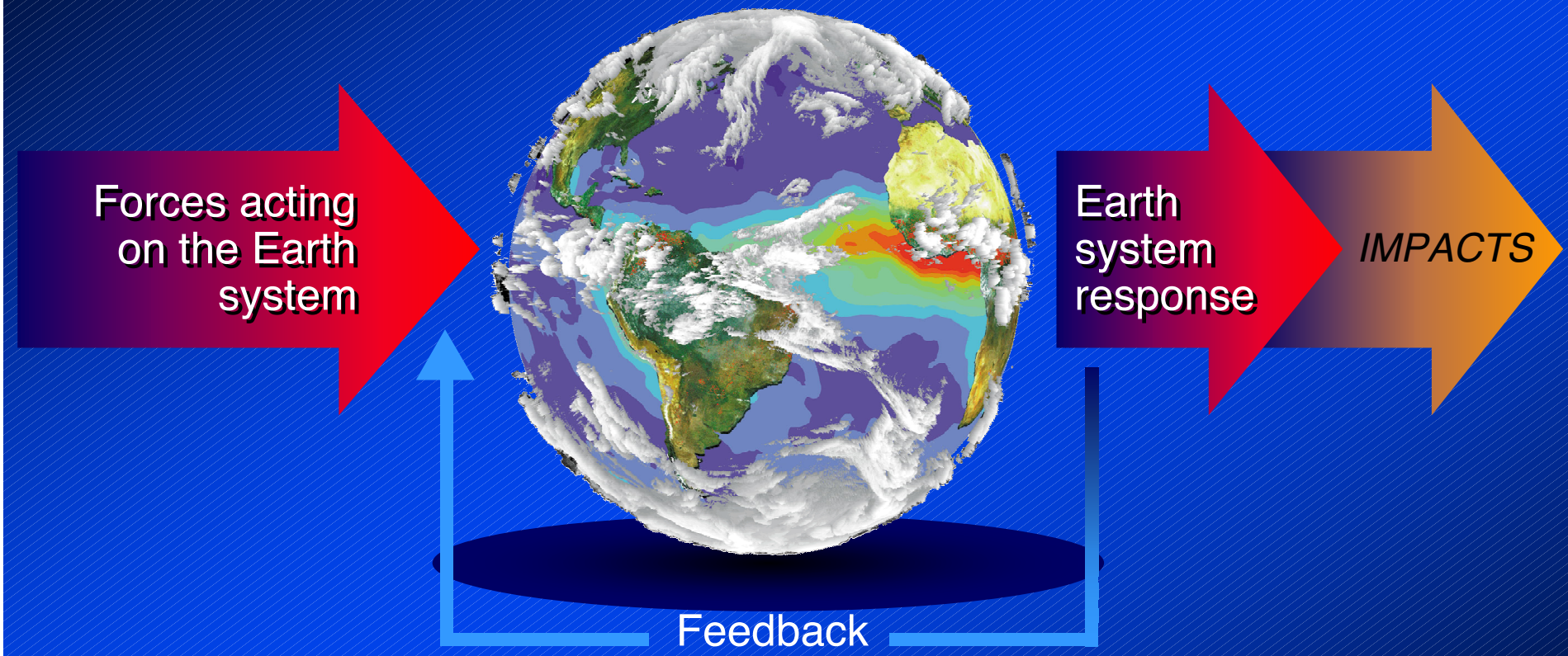
1 Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth

2 Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology

3 ***Develop and adopt advanced technologies to enable mission success and serve national priorities***

We provide objective, scientific information for decision-makers

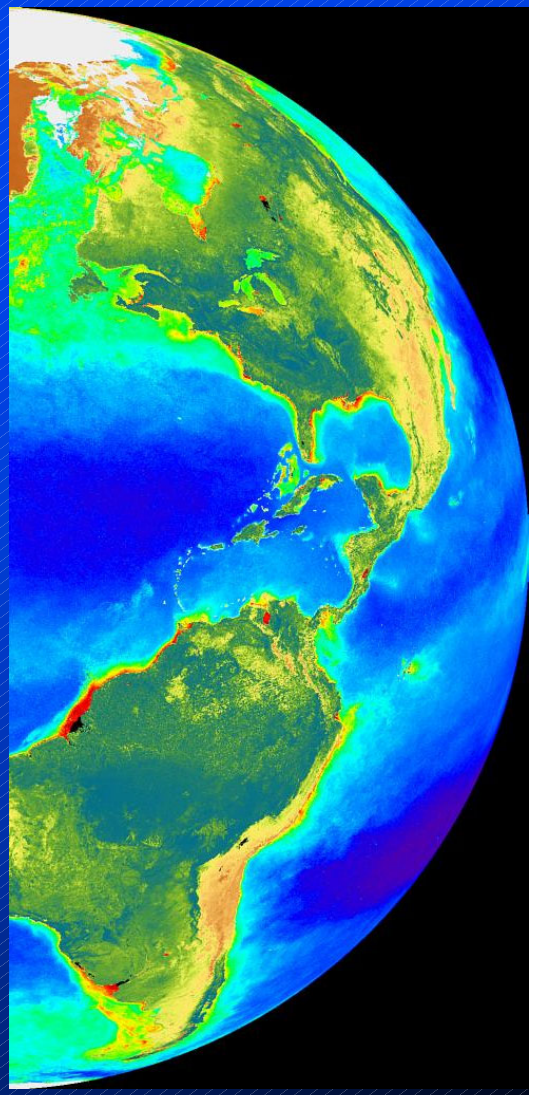
The Earth System Science Concept



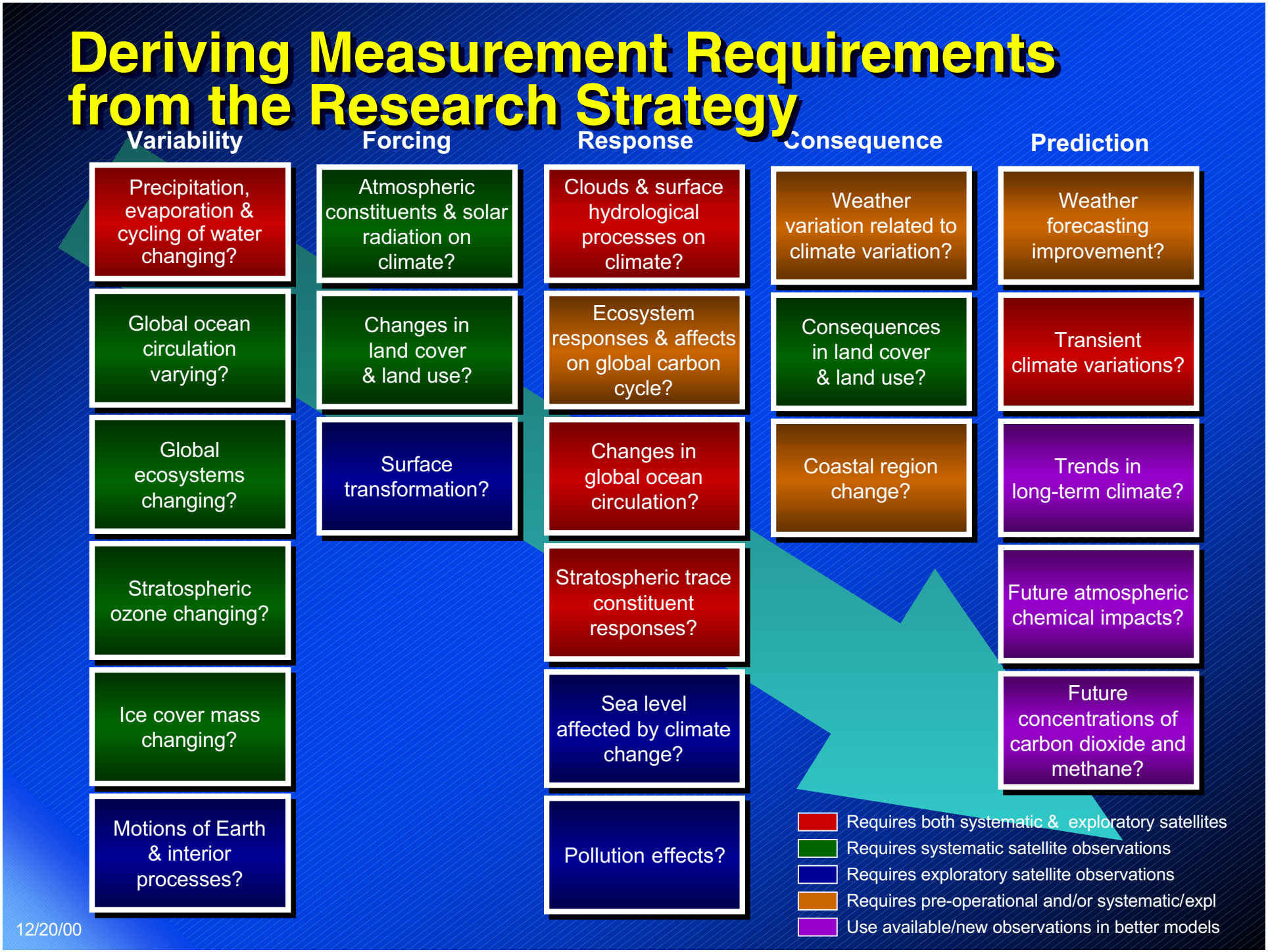
Of the total forcing of the climate system, 40% is due to the direct effect of greenhouse gases and aerosols, and 60% is from feedback effects, such as increasing concentrations of water vapor as temperature rises.

Science: How is the Earth Changing and What Are the Consequences for Life on Earth?

- **How is the global Earth system changing?**
- **What are the primary forcings of the Earth system?**
- **How does the Earth system respond to natural and human-induced changes?**
- **What are the consequences of changes in the Earth system for human civilization?**
- **How well can we predict future changes to the Earth system?**



Deriving Measurement Requirements from the Research Strategy



Systematic Measurement Missions

EOS Era

Terra, Aqua	• NPOESS Preparatory Project (2005/06)
Landsat 7	• Landsat Data Continuity Mission (2005)
TRMM	• Global Precipitation Mission (2007)
TOPEX, Jason	• Ocean Topography Mission (2006)
QuikSCAT, SeaWinds	• Ocean Surface Winds (2006)
TOMS, OMI	• Total Column Ozone/Aerosols (2008)
ACRIMsat, SORCE	• Solar Irradiance (2006)

Exploratory Measurement Needs

How are global precipitation, evaporation, and the cycling of water changing? (V1)

What are the motions of the Earth and Earth's interior? (V6)

What trends in atmospheric constituents and solar radiation are driving global climate? (F1)

How is the Earth's surface being transformed…? (F2)

What are the effects of clouds and surface hydrological processes on climate change? (R1)

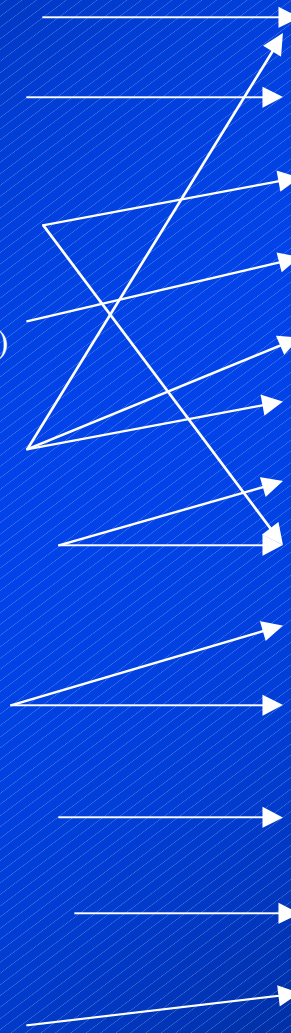
How do ecosystems respond to and affect global environmental change and the global carbon cycle? (R2)

How can climate variations induce changes in global ocean circulation? (R3)

How do stratospheric trace constituents respond to change in climate and chemical composition? (R4)

How is global sea level affected by climate change? (R5)

What are the effects of regional pollution on the global atmosphere…? (R6)



Soil moisture

Gravity field (*GRACE*)

Stratospheric aerosols *(PICASSO)*

Land surface topography/deformation

Cloud particle properties *(Cloudsat)*

Snow cover/Freeze-thaw transition

Biomass changes *(VCL)*

Carbon sources & sinks

Ocean salinity

Sea ice thickness

Atmospheric properties in tropopause region

Ice sheet velocity fields

Tropospheric ozone & precursors

Applications: to expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology

- Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private sector decision makers
- Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology

Applications Thrusts

- Aiming at partnerships to apply Earth Science data and technology to high priority national needs
  - Flood plain mapping with FEMA
  - Highway siting with DOT
  - Aviation safety (topography and atmosphere) with FAA
  - Precision agriculture with USDA
  - Improved weather prediction with NOAA
  - Water & other natural resource management with USGS & Statel/local governments
  - Digital elevation models with NIMA

Enabling Earth System Prediction

	TODAY	Goals for 2010
Weather	3-Day forecast at 93%*	5-Day forecast at >90%*
	7 Day forecast at 62%*	7-10 Day forecast at 75%*
	3 day rainfall forecast not achievable	3 day rainfall forecast routine
	Hurricane landfall +/-400Km at 2-3 days	Hurricane landfall +/-100Km at 2-3 days
	Air quality day by day	Air quality forecast at 2 days
Climate	6-12 month seasonal prediction experimental; achieved an understanding of El Nino mechanics	6-12 month seasonal prediction routine; 12-24 months experimental
	Decadal climate prediction with coarse models and significant uncertainties in forcing and response factors	10 year climate forecasts experimental; moderate to high confidence in forcing & response factors
Natural Hazards	Demonstrate centimeter-level measurement of land deformation	Continuous monitoring of surface deformation in vulnerable regions with millimeter accuracy
	Accurate characterization of long-term tectonic motions, but no short-term earthquake forecast capability	Improved temporal dimension of earthquake & volcanic eruption forecasts
	Accurate characterization of volcanic activity, but no long-term prediction accuracy	Improve post-eruption hazard assessment

** Accuracy refers to sea level pressure forecasts over Northern Hemisphere during winter.*

Future Prediction Goals

Increased Scientific Understanding & Improved Models

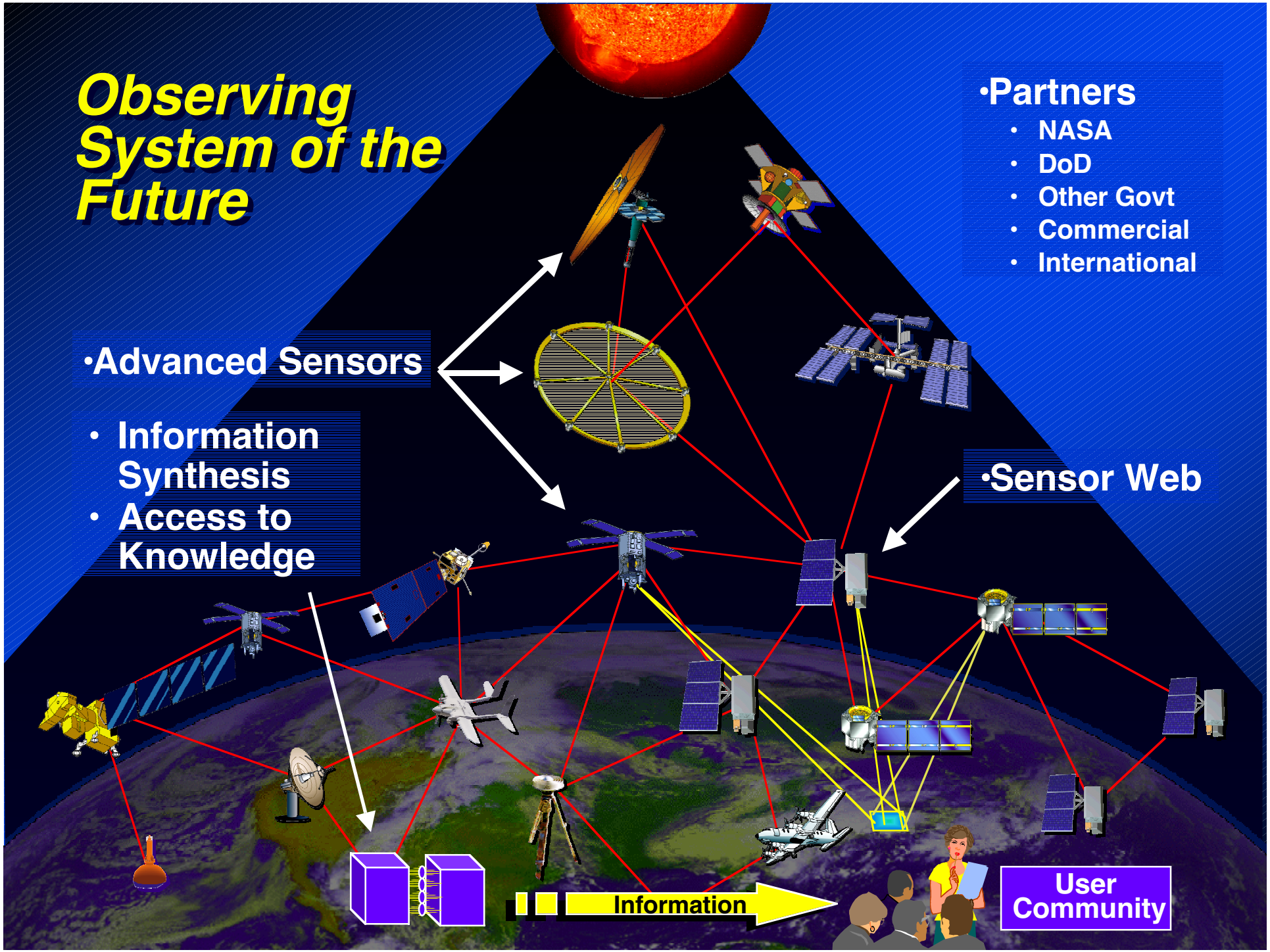
Improved Sensors & Advanced Platforms

Enable:

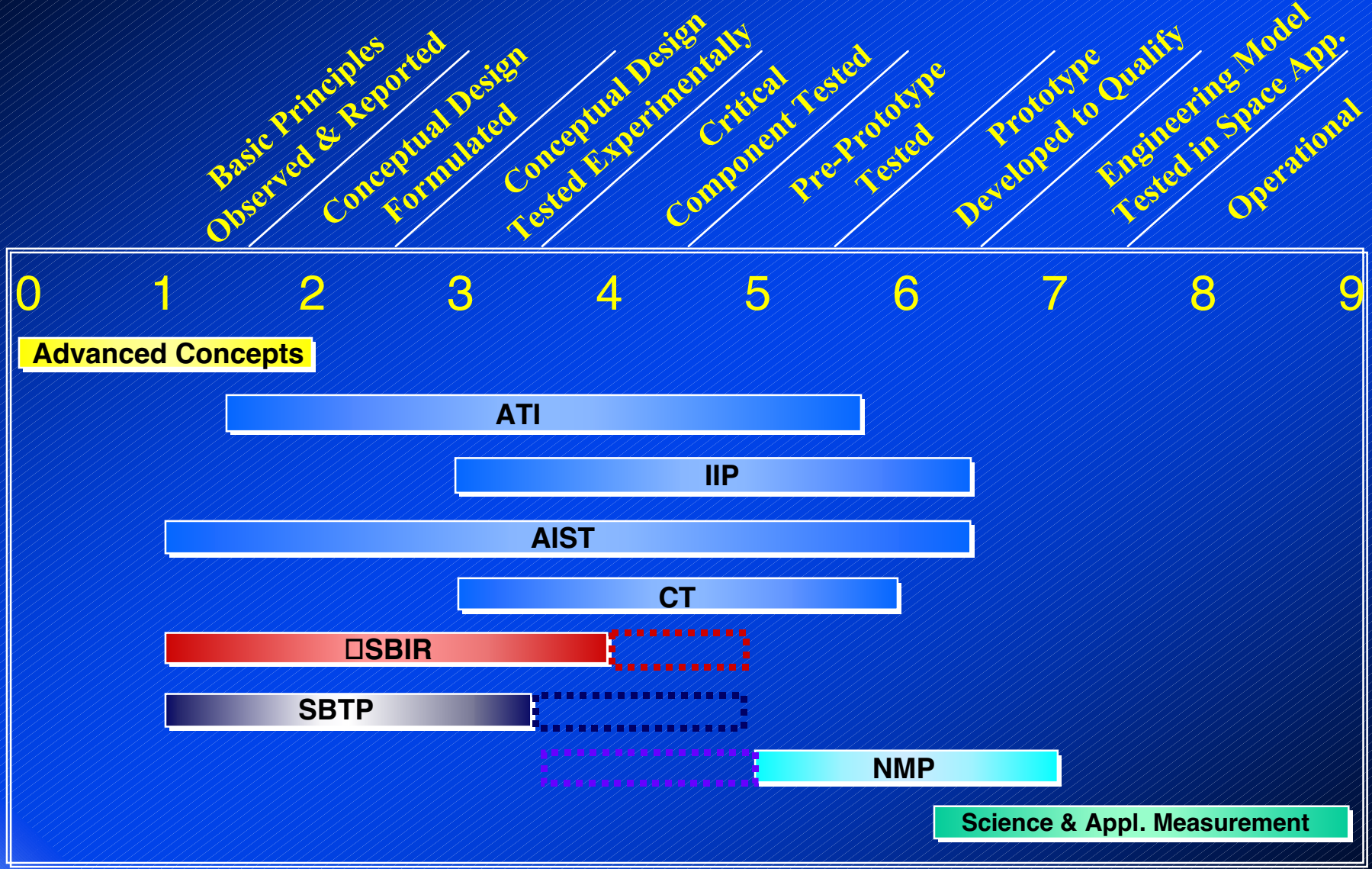
- 2 week weather prediction
- 10 year climate forecasts
- 12 month rain rate for agriculture
- 10 day forecast of pollution alerts
- 60 day volcanic eruption prediction
- 15-20 month El Nino forecast

Lower Launch Costs

Advanced Information Technology Systems


Observing System of the Future
•Partners
• NASA
• DoD
• Other Govt
• Commercial
• International
•Advanced Sensors
• Information Synthesis
• Access to Knowledge
•Sensor Web
Information
User Community

Technology Program Readiness



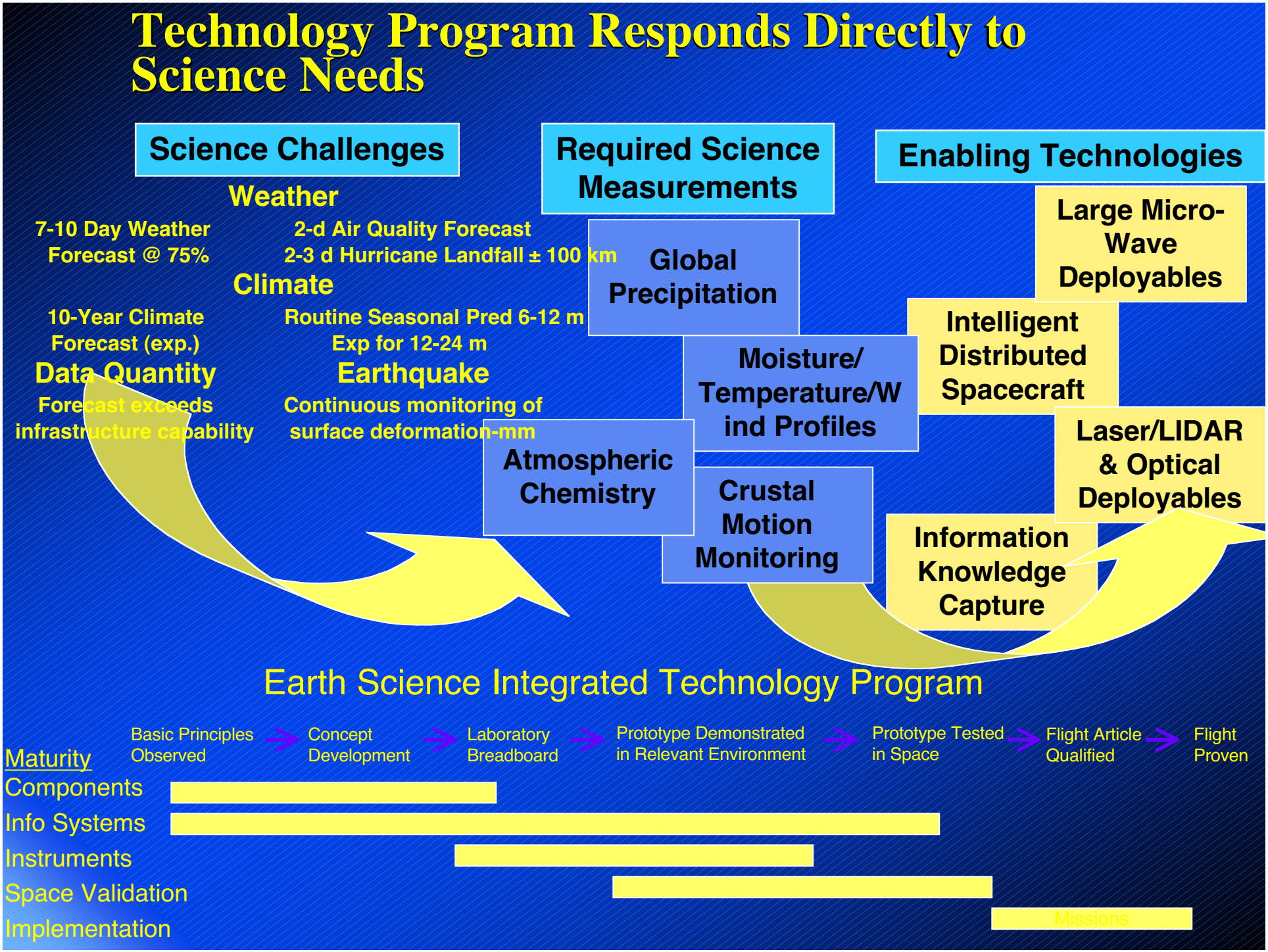
Earth Science Technology Scorecard

Program	Solicitation	No. of Proposals	Projects Awarded	Funding
Instrument Incubator Program	NRA '99	123	27	$39M
Advanced Technology Initiatives Component Technologies	NRA '00	104	23	$14M
Advanced Information Systems	NRA '00	117	30	$26M
Instrument Incubator Program	NRA '01	64	11	$28M

Technology Infusion:

- 2 IIP Projects are flying on CAMEX-4
- 2 ESTO-supported technologies are being used for an NPP In situ Terminal
- Wide Area GPS Differential Technology being applied to precision agriculture
- Several technologies incorporated in recent ESSP proposals
- 9 new technologies demonstrated on EO-1

Technology Program Responds Directly to Science Needs



Earth Science Technology Program

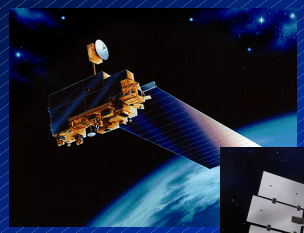
- We have implemented an advanced technology program to enable us to answer specific science questions
  - Make new measurements possible
  - Make existing measurements cheaper
  - Enable the transfer of mature technologies to operational systems
- This conference is intended to help us reap the benefits of the Technology Program

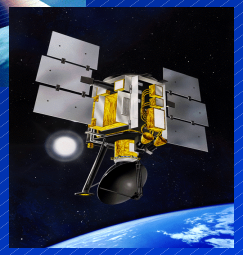
It's a Pathway, Not a Sandbox !

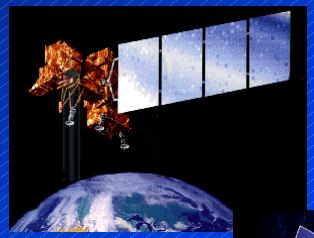
BACKUP

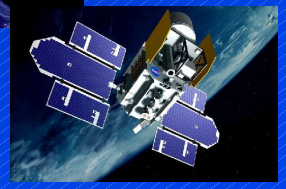
Examining Practically Every Aspect of the Earth System From Space

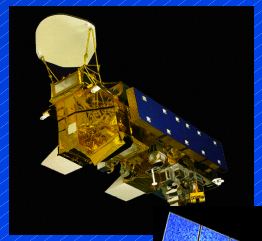
Systematic Missions - Observation of Key Earth System Interactions


Terra


QuikSCAT


Landsat 7

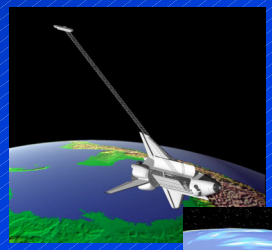

ICEsat

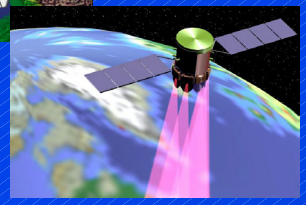

Aqua

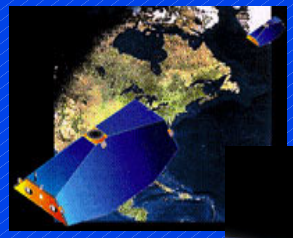

Jason-1


Aura

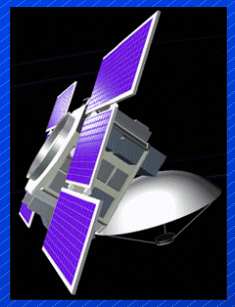
Exploratory - Explore Specific Earth System Processes and Parameters and Demonstrate Technologies

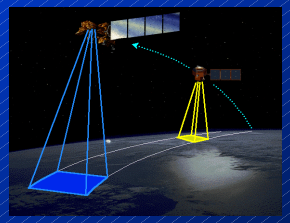

SRTM

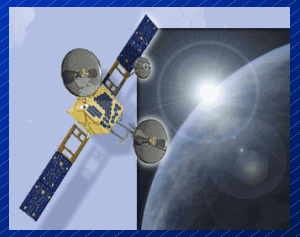

VCL


GRACE


PICASSO

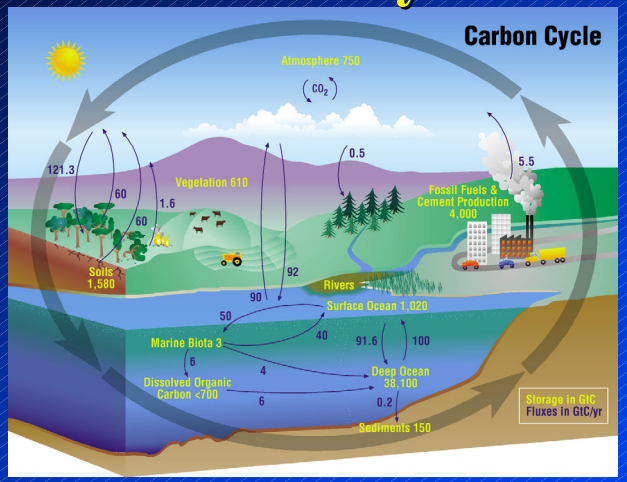

Cloudsat


EO-1

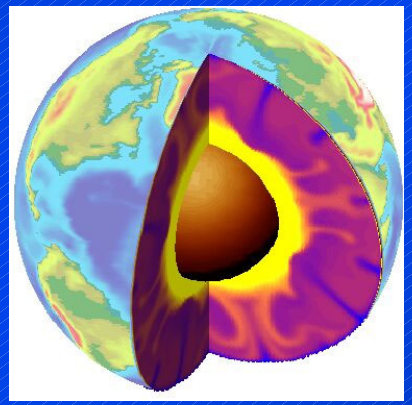

EO-3

ESE Research Focus Areas

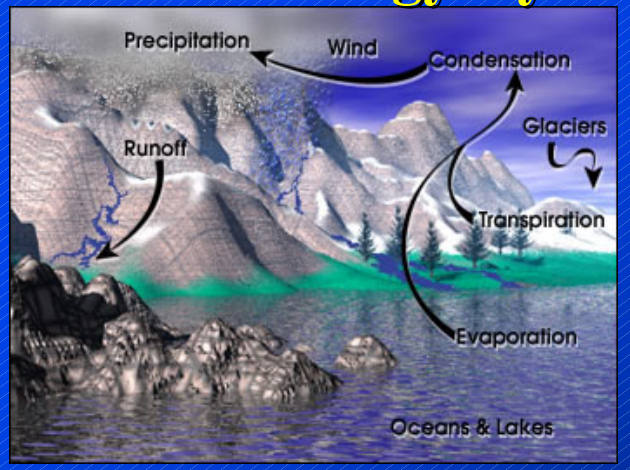
Carbon Cycle



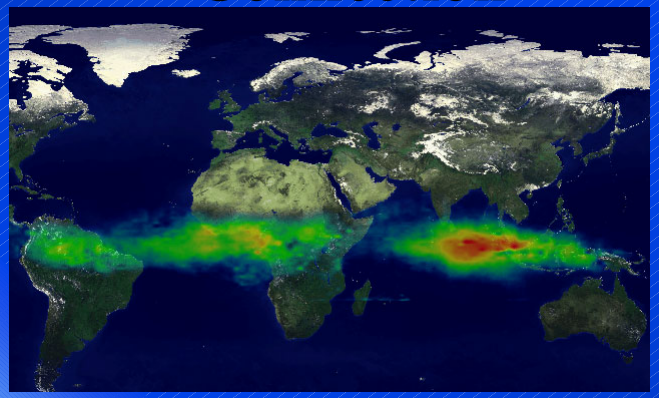
Solid Earth & Natural Hazards



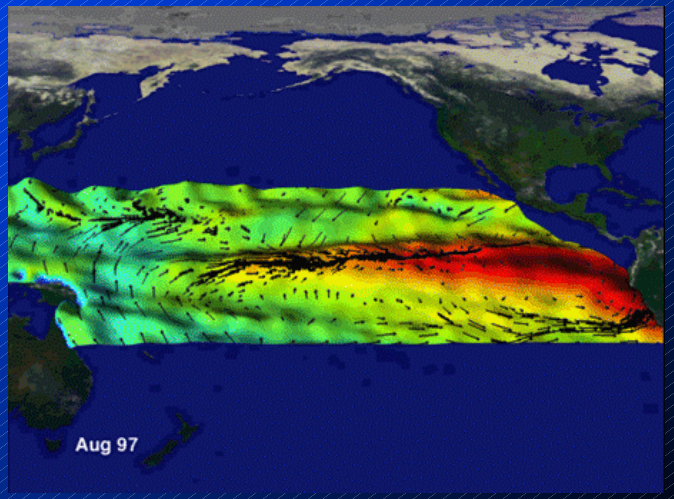
Water & Energy Cycle



Chemistry Climate Connection

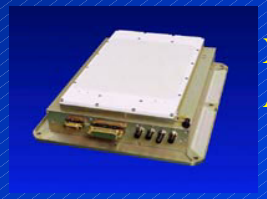


Climate & Weather

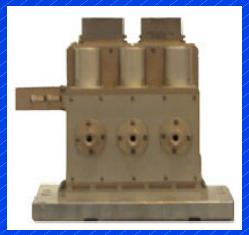


EO-1: Validation of 9 Breakthrough Technologies

- **Advanced Land Imager: reduce costs for future missions**
- **Hyperion: enables new earth science capabilities**



X-Band Phased Array Antenna

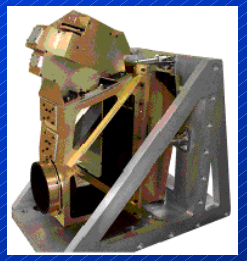


Leisa Atmospheric Corrector

Advanced Land Imager

Carbon-Carbon Radiator

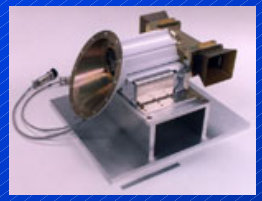
Spacecraft



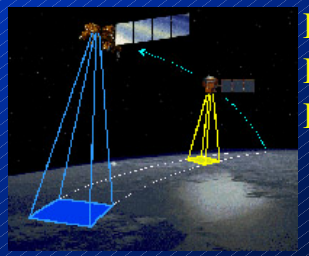
Hyperion

Wideband Advanced Recorder Processor

Lightweight Flexible Solar Array



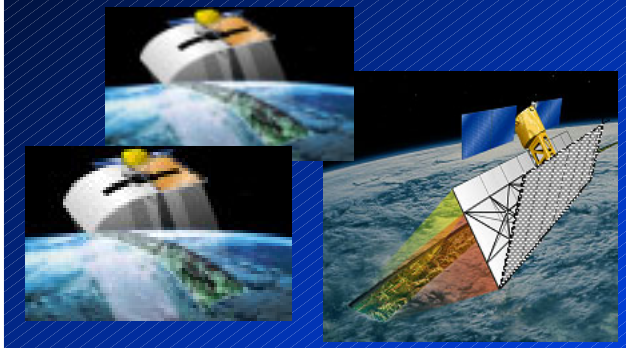
Pulsed Plasma Thruster



Enhanced Formation Flying

Key Technology Needs for Earth Science

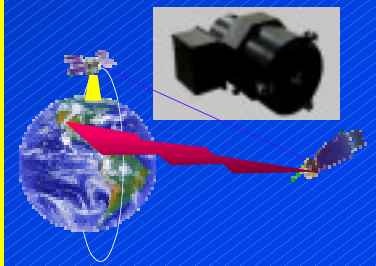
Large Antennas



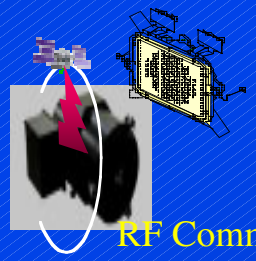
- deployment,
- rigidization,
- control

Enables improved soil moisture and global precipitation science capabilities

Communications



Optical Comm from LEO to GEO



RF Comm demonstrates Ka-band in space

- Space to space Comm
- Acquisition, Pointing and Tracking

Technology significantly improves spatial/spectral resolution and temporal coverage for science missions

Lasers and Deployable Telescopes

DIAL Lidar with 3-m class deployable telescope

Enable atmospheric chemistry, aerosols and winds science measurements

Distributed Platforms

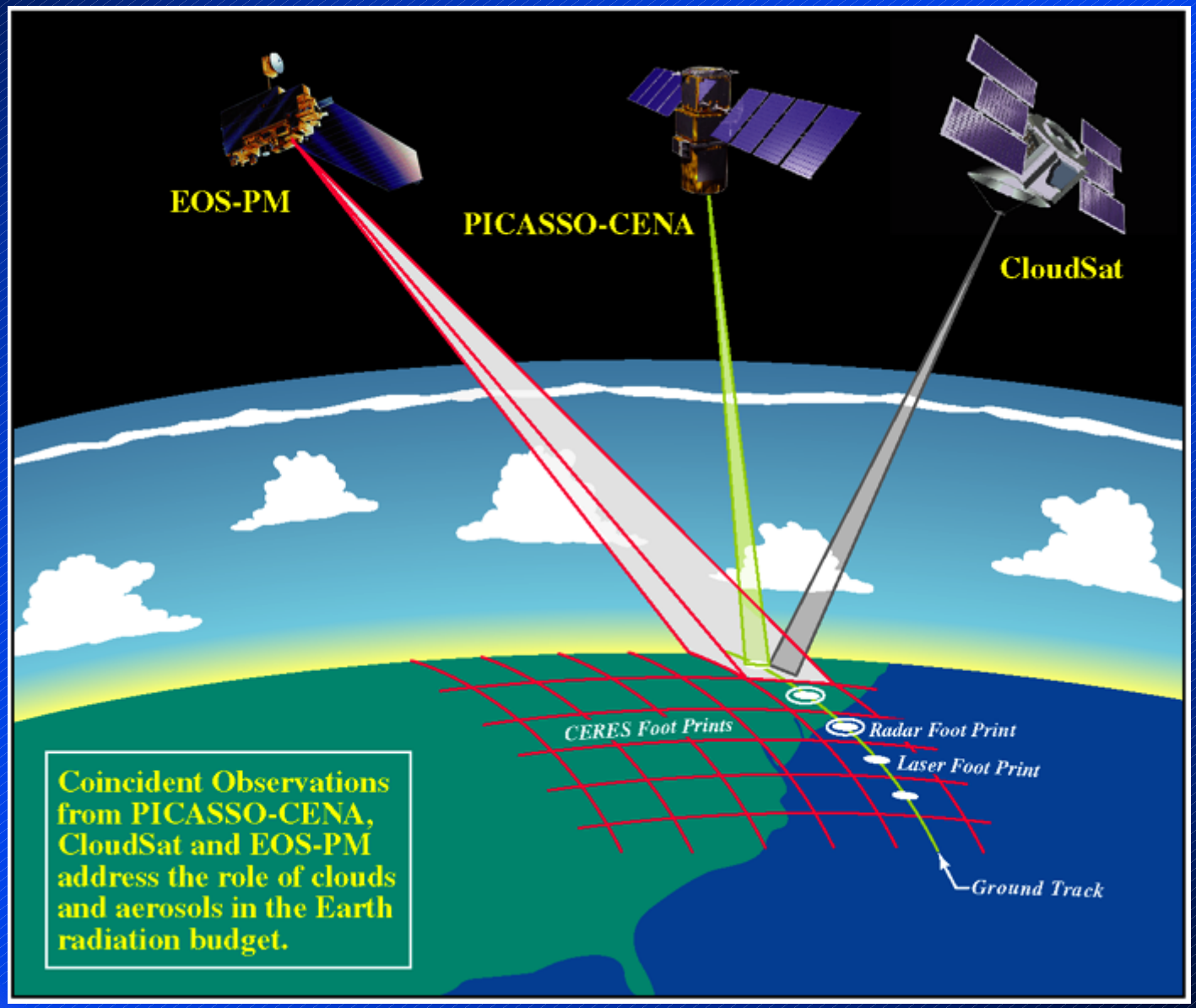
- Autonomy
- Deployment
- Maneuver Planning & Execution
- Planning and Scheduling
- Fault Detection and Isolation
- Spacecraft Pointing
- Safehold

Distributed platforms will lead to "sensor webs" for ocean and atmospheric science missions.

Summary

- **The Earth Science Technology Program has successfully initiated the process of science driving technology development which enables missions**
  - Reduced cost, mass, and size components and systems have been developed
  - New measurements have been enabled
  - New information system technologies have been demonstrated
  - Science missions are initiated only when technologies are ready
  - Earth Science technology investments are focused, cost effective, and leveraged through strategic partnerships
- **Earth Science research and application excellence needs a continuing strong technology program**
  - Must pursue a balanced and diverse portfolio of technology investments that addresses all TRL levels necessary to future mission success
  - The best results come from the current approach which uses broad, open competition with peer review of proposals

Formation Flying



EO-1 and Landsat